

Emission Spectroscopy from Laser-Produced Plasmas of Relevance to Source Development

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1.Introduction

Water window transmission x-ray microscopy (WW-TXM) has great potential for high resolution three dimensional tomographic imaging of frozen cells. Previous literature has shown the most attractive sources to be the 1s – 2p doublet of hydrogen like nitrogen at 2.48nm and the 1s² -1s2p line of helium like nitrogen at 2.88nm^[1]. We present a novel, low debris, plasma source from a solid target.

2.Setup

The experimental setup used to produce the plasma under investigation is shown in figure 1. A 6ns, 1064nm, Nd:YAG laser pulse with energy of 680mJ irradiated the target. A range of power densities was achieved by varying the lens – target distance. Spectra from the plasma was analysed using a 2 meter grazing incidence soft x-ray spectrometer shown in figure 2^[2].

3. Spectral Results

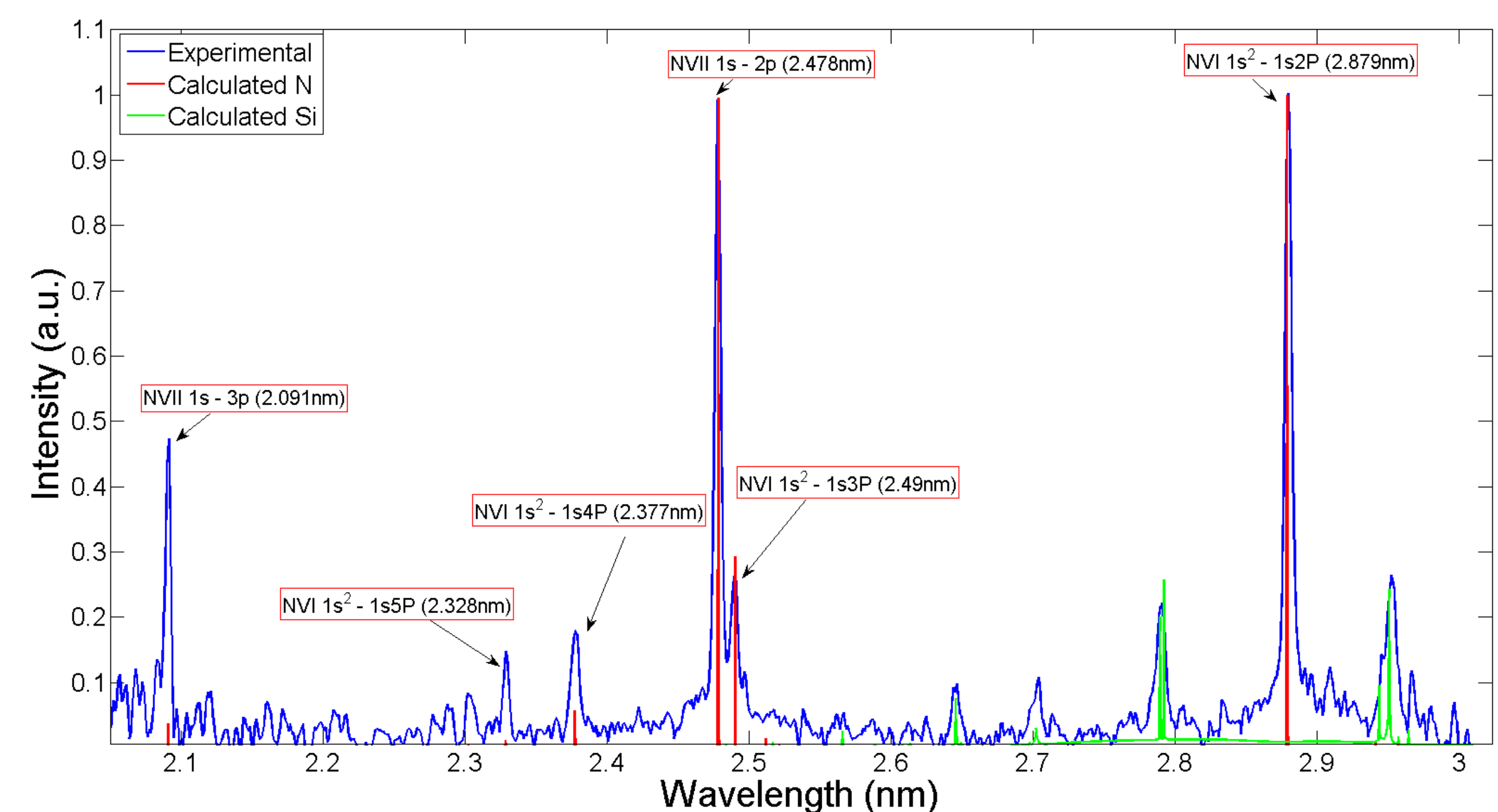


Figure 4: Background corrected spectra with calculations from FLYCHK

Experimental spectra with calculations from FLYCHK^[3] are shown in figure 3. An electron temperature of 94 eV was found to give the best agreement with experiment. The line width of both the Hydrogen like 1s – 2p and the Helium like 1s² -1s2p was instrument limited at 0.053Å. This gave a lower limit of $\lambda/\Delta\lambda$ of 505 and 669 respectively. This is in the higher range of reported values^[1].

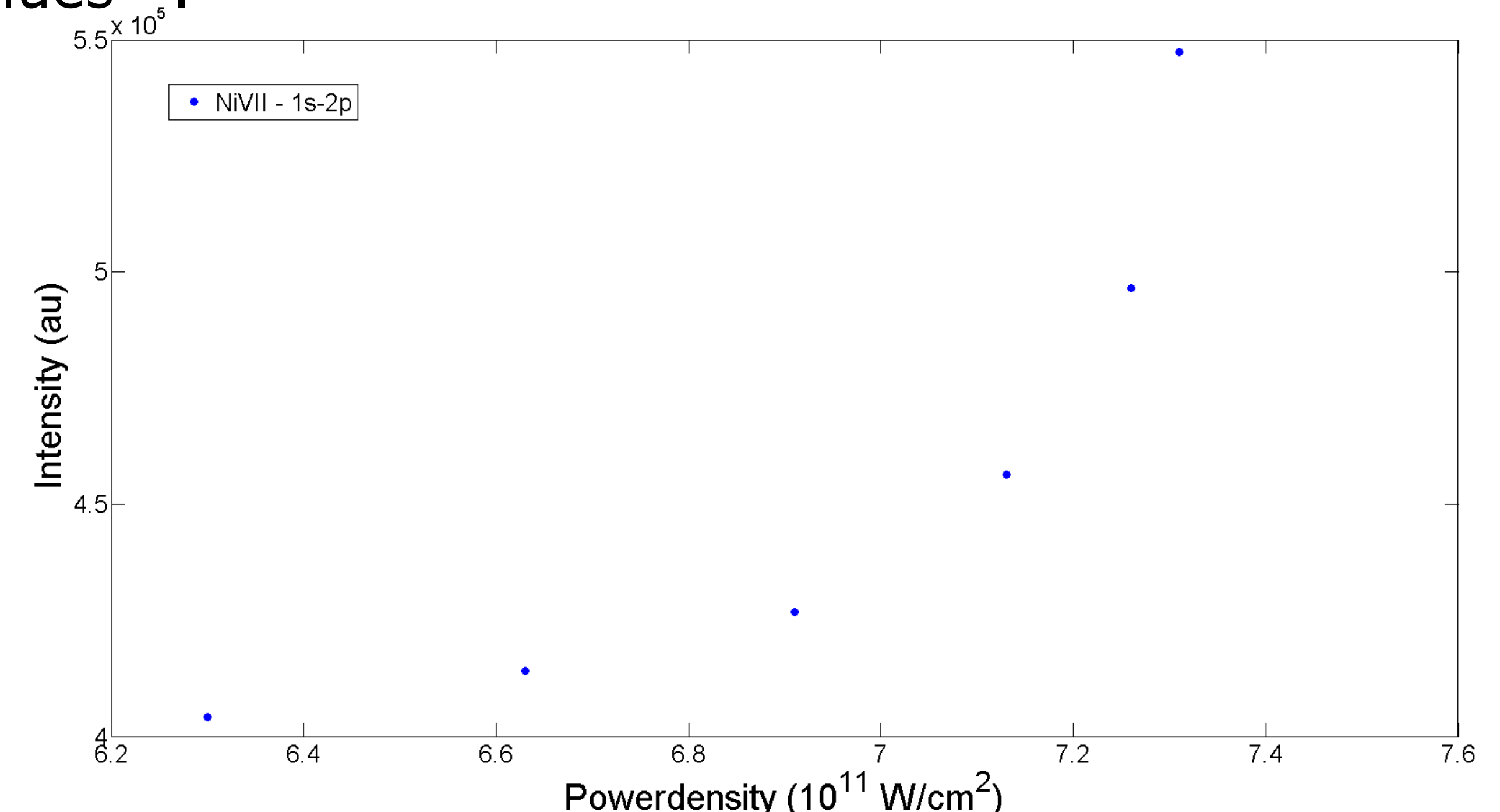


Figure 5: A plot of varying lens position against

6.Future Work

Absolute intensity measurements will be made with a photodiode and Al/V filter. This will allow the measurement of conversion efficiency. A 160ps Nd:YAG laser pulse with a peak energy of 500mJ will be used to obtain a hotter plasma and thus increase the output from the Hydrogen like Lyman alpha line. A more accurate value for the debris will be obtained and the ion emission will be characterised using an electrostatic spherical sector analyser.

7.References

- [1] Jean Francois Adam and Jean-Pierre Moy, “Table-top water window transmission x-ray microscopy :Review of the key issues, and conceptual design af an instrument for biology” Rev. Of Sci. Instrum. **76**, 091301 (2005)
- [2]High Resolution duo-multichannel soft x-ray spectrometer for tokamak plasma diagnostics – J.L. Schwob – Rev. Sci. Instrum. **59** (9) (1987)
- [3] <http://nlte.nist.gov/FLY/>
- [4] R.Lebert , G.Schriever, T. Wilhein, and B.Nieman- Soft x-ray emission of laser-produced plasma using a low debris cryogenic nitrogen target – J Appl Phys. **84**, 6 (1998)

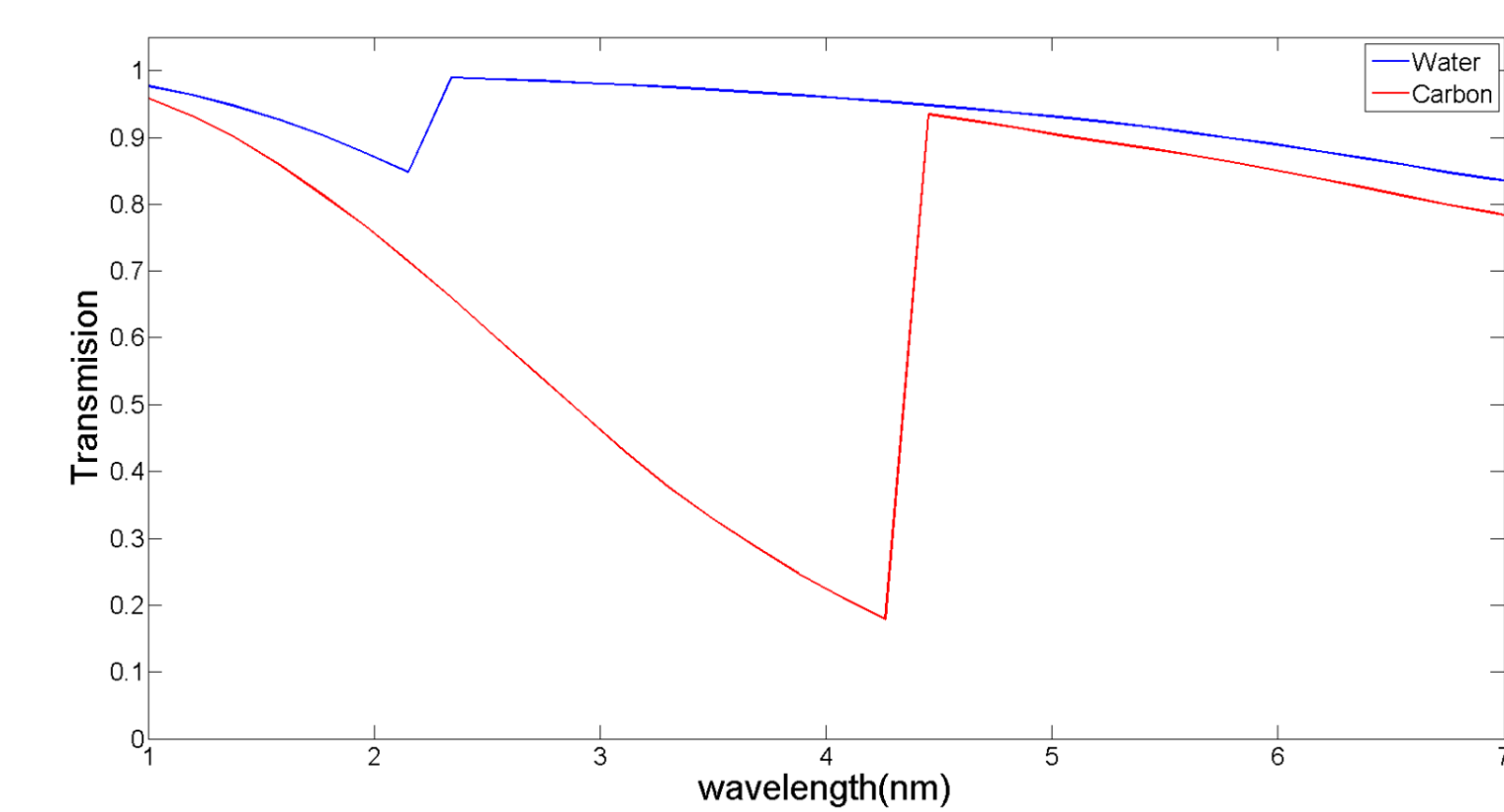


Figure 1: A plot of water and carbon's transmission coefficients in the water window region

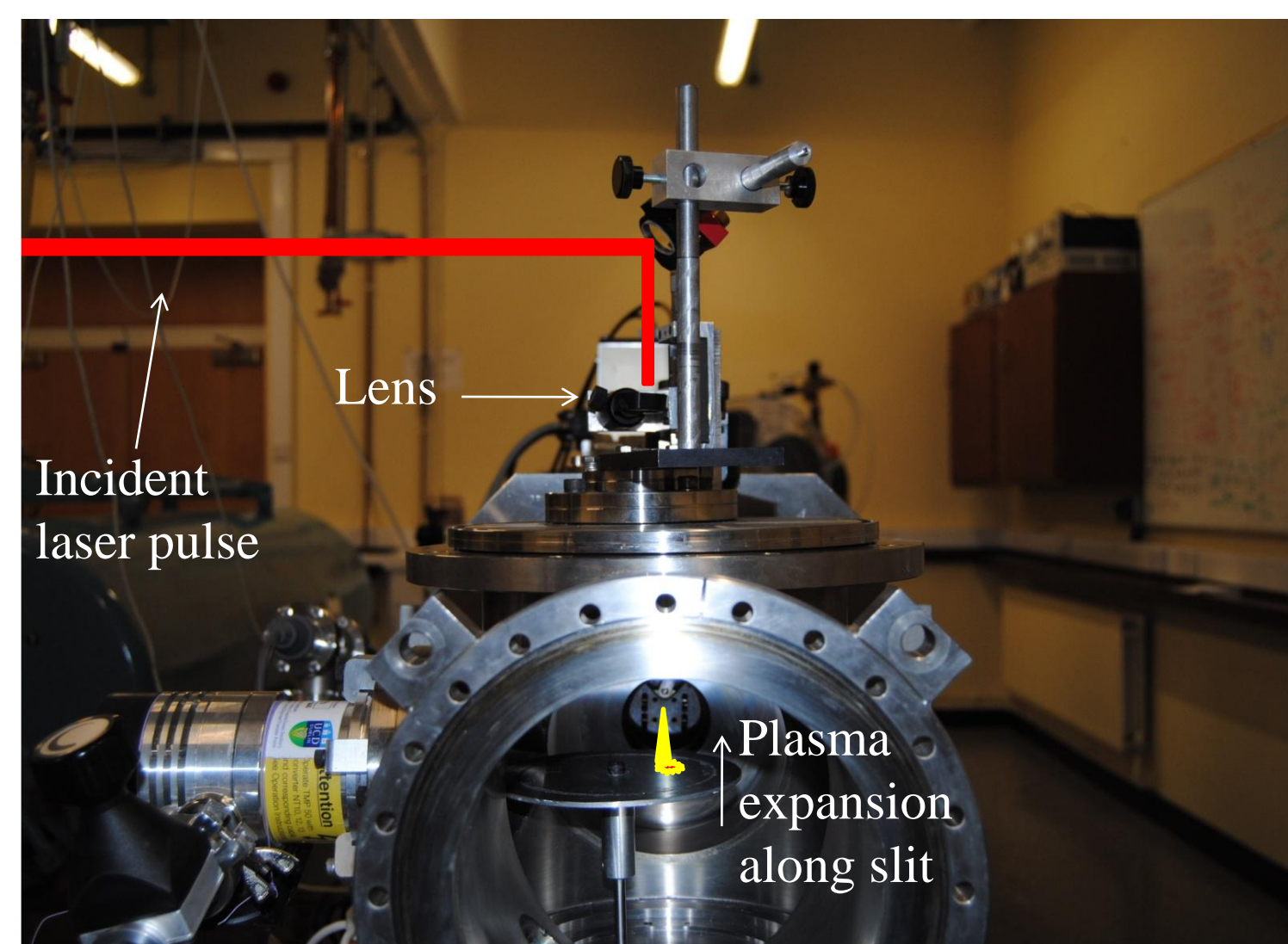


Figure 2: Image of target chamber used

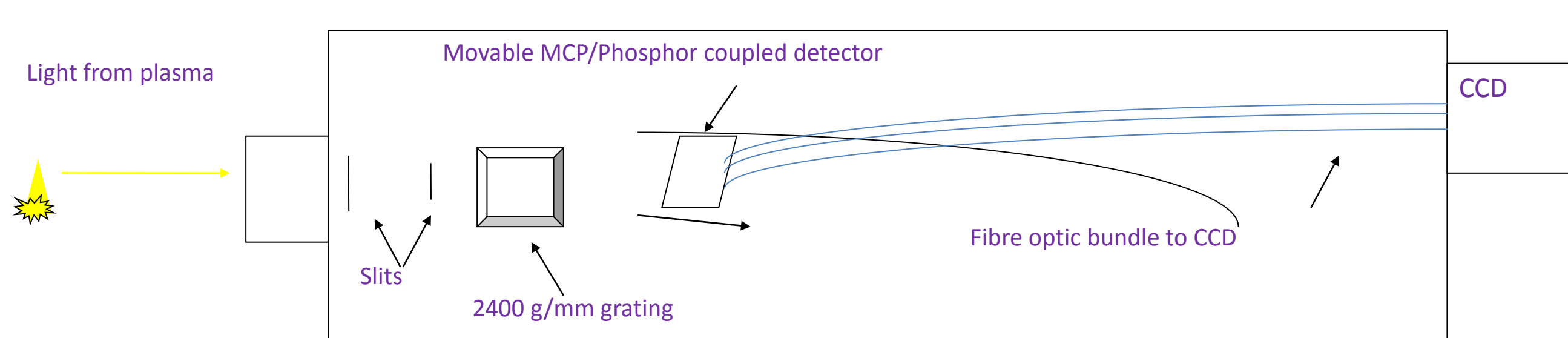


Figure 3: Schematic of Schwob/Fraenkel soft x-ray spectrometer

4. Power density variation

A plot of intensity of the NVII Lyman –alpha against calculated power density is shown in figure 5. The intensity of the line increases with increasing power density. We were limited in increasing the power density any further by our incident laser parameters.

5.Debris

The presence of a witness plate allowed for some quantification of the debris. After 10,000 shots the witness plate was examined under a florescence microscope ,shown in figure 6. The limit of the resolution of the microscope allowed the counting of particles over 1 micron only. This gave us an estimation of the debris to be approximately 1 µg/sr/pulse, considerably lower than from previously reported solid, nitrogen containing targets^[4].

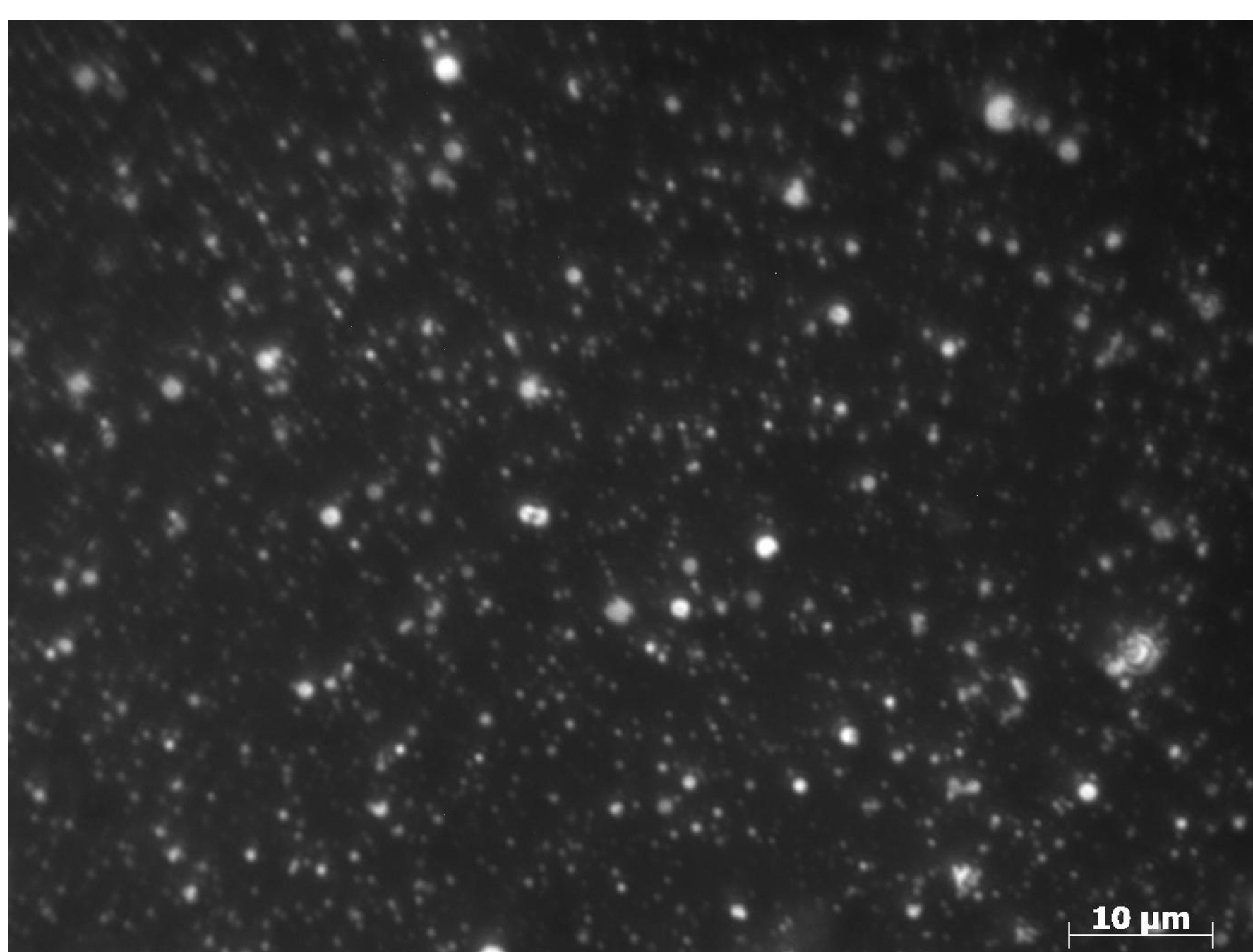


Figure 6: 100x magnification micrograph image of witness plate

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